UAS Control Station Human Factors: Sensory Information

Federal Aviation Administration

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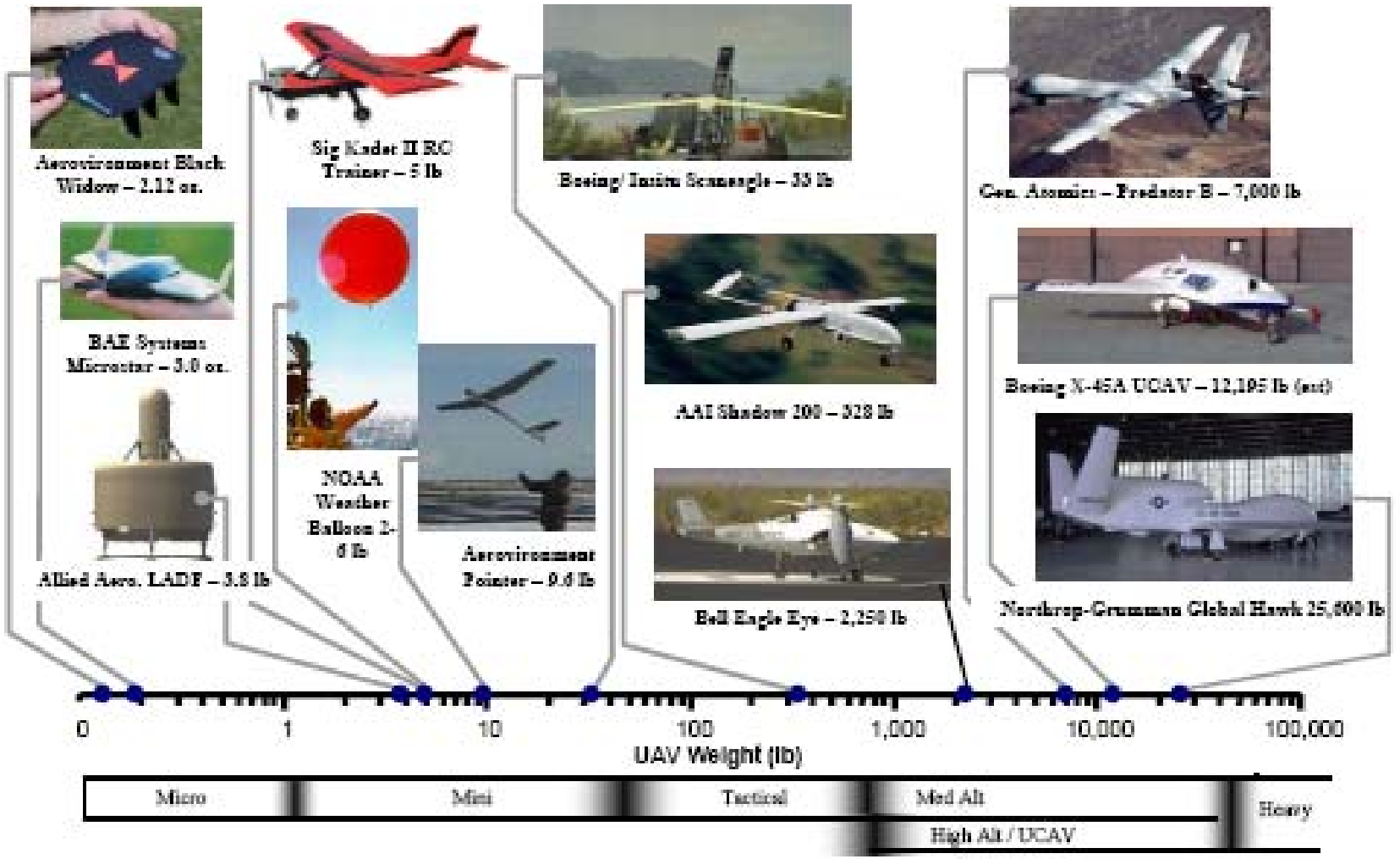
Overview

- Potential human factors issues related to control station design
- Pilot sensory information
- Detecting anomalous events
- Monitoring normal events
- Comparing unmanned and manned sensory information
- Conclusions and recommendations

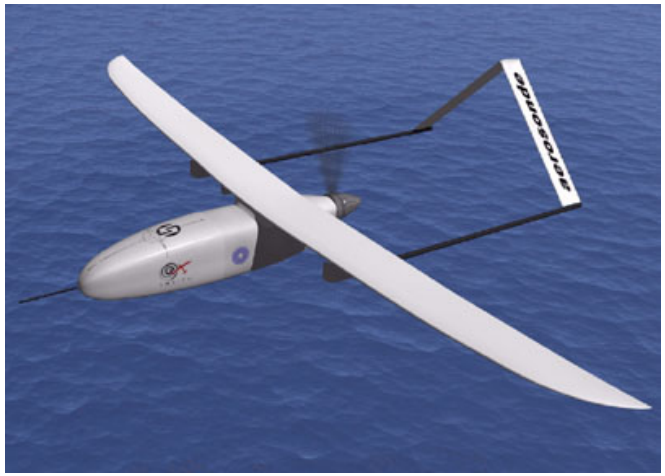
UAS Development

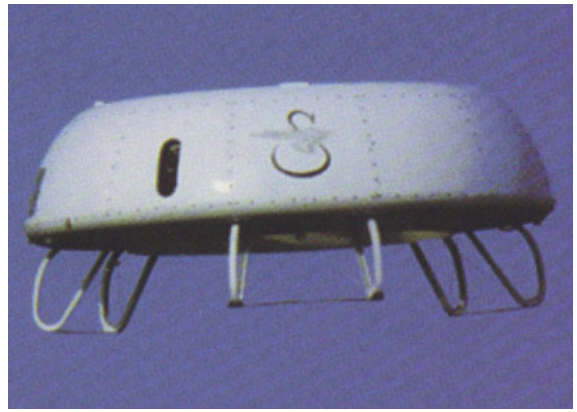
- Over 500 unmanned aircraft systems in existence
- Over 200 UAS manufacturers
- 43 countries are developing UAS (including North Korea and Iran)
- 70% of the current systems are for military use, however, the number of non-military applications is increasing
- In the US, non-military applications include border patrol, emergency situation awareness (e.g., Hurricane Katrina aftermath), and scientific applications such as crop inspection and atmospheric measurements.

Size (from Weibel and Hansman, 2005)



Airframes and Engines





Controls Vary Widely Across Systems

Human Factors Issues Divide Into Two Types

- Embryonic issues can be overcome through the establishment of standards and procedures.
  - Lack of standardization across control station designs
  - Evolving UAS pilot training and certification requirements
  - No clear understanding of how air traffic controllers will interact with these systems
- Endemic issues are a result of the nature of these systems. Steps can be taken to compensate but not to eliminate.
  - Data link issues
  - Differences in pilot sensory information from manned aircraft

Pilot Sensory Information Categories

Visual Information

• Foveal Vision – measured as visual acuity with a Snellen chart

• Visual Accommodation

  • from 2-4ft inside cockpit to thousands outside

  • provides info regarding distance (at short distances)

•Color Vision

  • 8-10% of male population has red/green deficiency

  • 1-2% males blue/yellow deficiency

• Peripheral Vision

  • provides info regarding object motion and relative motion of aircraft

Pilot Sensory Information Categories –cont.

- **Auditory Information**
  - Changes in ambient noise are useful pilot cues
- **Vestibular Information**
  - Aircraft movement - yaw, pitch, roll, and acceleration
- **Proprioceptive and Kinesthetic Information**
  - Movement of yoke and rudders and the sensing of gravitational forces on the body
- **Haptic Information**
  - Sense of touch, shape and feel of controls, vibration
- **Sense of Smell**
  - Sometimes the first indication of trouble

Pilot Sensory Information for Anomalous Events

As an example, information regarding loss of engine was taken from several FAA documents. This is a table reproduced from one document.

	PROBLEM FLIGHT PHASE	SYMPTOM	TRAINING ACTION
SURGE	***TAKEOFF > V1***	LOUD BANG. (repetitive) N1/N2 Drop, EGT Increase, AIRCRAFT VIBRATION, P0SSIBLE YAW	SIMULATE LOUD NOISE, SUDDEN AIRCRAFT SHUDDER, FLUCTUATION OF ENGINE PARAMETERS N1, N2, & EPR DECREASING, EGT INCREASING, TRAIN TO KEEP CONTROL OF THE AIRCRAFT, CONTINUE TAKEOFF, CLIMB TO A SAFE ALTITUDE THEN THROTTLE BACK TO CLEAR SURGES AND REAPPLY POWER AND TROUBLESHOOT PER CHECKLISTS
SURGE	***TAKEOFF < V1***	LOUD BANG (usually 1 or 2). N1/N2 drop, EGT increase, AIRCRAFT VIBRATION, YAW	SIMULATE LOUD NOISE, SUDDEN AIRCRAFT SHUDDER, FLUCTUATION OF ENGINE PARAMETERS N1 & N2, & EPR DECREASE WHILE EGT INCREASES, TRAIN TO REJECT THE TAKEOFF

Pilot Sensory Information for Loss of Engine

Sensory Information	Manned	Unmanned
Engine noise	Yes	No
Engine displays	Yes	Yes
Auditory warning	Yes	Yes*
Aircraft yaw (for multiengine aircraft)	Yes	No
Aircraft vibration	Yes	No
Change in feel of control forces	Yes (unless fly-by-wire)	No
Other aircraft displays	Yes	Yes

Pilot Sensory Information for Icing

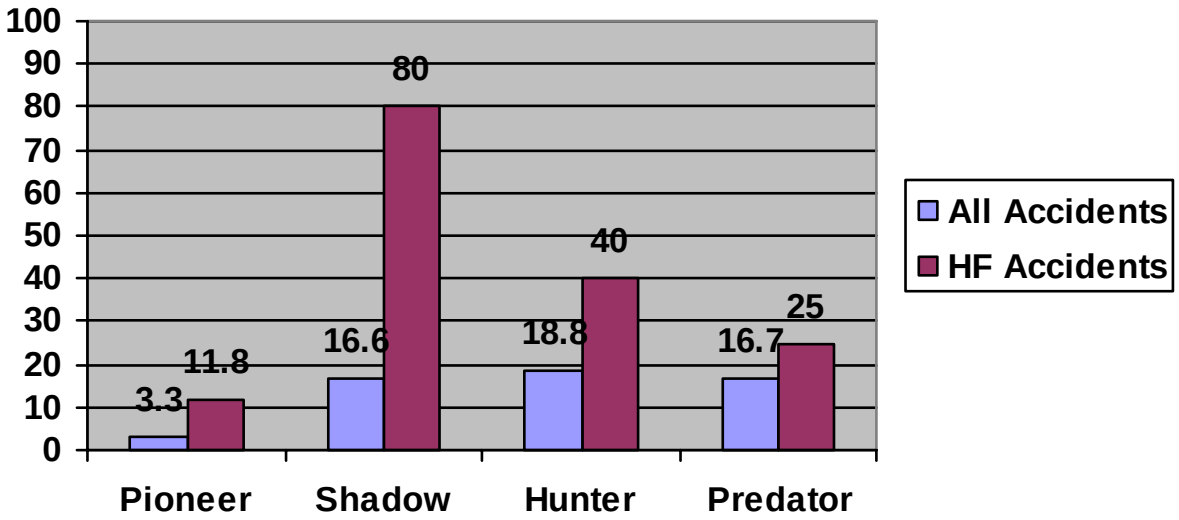
Sensory Information	Manned	Unmanned
Engine sound change	Yes	No
Engine displays	Yes	Yes
Visible accumulation of ice on aircraft	Yes	No
Aircraft vibration	Yes	No
Change in feel of control forces	Yes (unless fly-by-wire)	No

Pilot Sensory Information for Change in Power

Sensory Information	Manned	Unmanned
Change in sound of engine	Yes	No
Aircraft display of power setting, airspeed and attitude	Yes	Yes
Change in speed of aircraft (kinesthetic information	Yes	No
Visual out-the-window indications of change in speed	Yes	No

Sensory Deficiencies and UAS Accidents

- Tvaryanas, Thompson & Constable (2005)
  - 10% of accidents (across systems) due partially to misperception
  - 26.5% of Predator accidents attributed partially to lack of sensory feedback
- Williams (2004) data reviewed



Conclusions and Recommendations

- Pilots of manned aircraft have far more types of sensory information than pilots of unmanned aircraft
- The effects of this lack of sensory information on the pilot are not fully known, but it is likely that one critical effect is on the ability of the pilot to recognize and diagnose anomalous events
- Training should include the diagnosis of an event in addition to just the response
- Control station warnings and diagnostics should capture the attention of the pilot when necessary and should provide the pilot with enough information to uniquely diagnose and react
- The use of other-than-visual (e.g., auditory, vibrotactile) information is recommended to ensure that pilots are alerted to highly critical events.

Questions?

Predator Control Station